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Networked Targeting

Good Morning. I'm Stephen Welby, and I'd like to talk to you this morning about a concept we in the DARPA Information Exploitation Office call Networked Targeting.

You've heard from Dick about the challenges being addressed by IXO, from Allan about the sensor work being pursued in IXO, and from Bob and Tom about the need to plan, synchronize, and extract critical knowledge to close the targeting loop. In the next few minutes I'll describe a critical system solution to the C4KISR target engagement problem—an approach that leverages the opportunity afforded by a highly dynamic, networked system-of-systems.

I'll describe what we mean by networked targeting technologies, discuss two programs in which the networked targeting concept is being applied, and identify some innovative, emerging opportunities in this area.

What drives us to look at Networked Targeting? U.S. forces have an unprecedented capability to target and engage an opponent over the full depth and breadth of the modern battle space. Future opponents must consider any fixed facility to be at risk to U.S. forces at any time during a conflict. In reaction to this capability, potential opponents have been increasingly relying on ground mobility—mobile surface-to-surface missiles and rockets, mobile air defense systems, and mobile command, control, and communications systems.

The survivability of these mobile threats depends on their ability to perform their missions and disperse before U.S. systems can target and engage them. This places a significant premium on technologies that enable U.S. forces to dramatically reduce their response time to short dwell, moving, and mobile threats—at any time and in any weather.

This challenge cannot be addressed without looking at the systematic interaction of the tools of modern strike warfare. Improvements only to sensors, weapons, synchronization and planning tools, or communication won't be sufficient. Instead we need to think about process, systems, technology, and tactics together to understand the ways that systems and technologies can be integrated in a machine-to-machine interaction to produce new, dynamic, and decisive results. We call this deeply interconnected approach to sensing, command and control, and strike: Networked Targeting.

Networked targeting technologies will address emerging targeting challenges by permitting multiple sensors, weapons, and C3I nodes to communicate over robust networks and rapidly and precisely target and engage short dwell, moving, or mobile threats. The networked targeting concept will utilize the proliferation of tactical data links to synchronize sensors and strike assets operating over large geographic areas.

Under the networked targeting concept, multiple sensors with differing fields of view will collaborate in real time to rapidly produce a single, correlated, precision-targeting solution against an emerging threat. This targeting solution can then be passed directly to networked precision strike weapons and perhaps be refreshed over time to provide updates to a weapon in flight. The sensor-sensor and sensor-weapon networks will permit synchronization of multiple platforms to yield more timely and precise targeting solutions than those available from any single sensor platform.

The enhanced precision offered by network targeting concepts will provide significant advantages, supporting increased lethality and strike effectiveness while minimizing the risk of collateral damage.

Two ongoing programs in IXO that utilize the networked targeting concept are the Affordable Moving Surface Target Engagement program (AMSTE) and the Advanced Targeting Technology Program (AT-CUBED).

AMSTE is focused on extending U.S. capabilities to permit standoff engagement of surface threat targets while they are on the move. The program will deny opponents the sanctuary of movement by enabling target engagement during the brief durations when mobile threats are stopped as well as throughout their full exposure timeline to U.S. sensors, including periods when threat assets are on the move. For some target types, the majority of their window of availability for engagement might be those times when they are in transit.

Tactics used by mobile threat systems today to avoid targeting (such as utilizing hide sites, transiting to mission locations, tearing down rapidly to move or reload to alternate attack positions) will largely be ineffective against AMSTE technologies. Networked targeting concepts for moving target engagement will leverage improvements in a number of supporting technologies, including:

- Current and planned highly-capable GMTI radar sensors,
- Current and planned precision-guided weapons, and
- Tactical communications networks such as Link-16.

AMSTE seeks to integrate these emerging capabilities using a system-of-systems approach, creating a networked targeting spine connecting sensors-to-sensors and sensors-to-weapons to enable the precise, rapid engagement of moving targets.

The AMSTE concept is not tied to a particular service platform, sensor, weapon, or doctrine. Instead AMSTE is a technological capability that can be leveraged by any number of weapon system architectures from strike air to surface missiles to long-range precision-guided, gun-launched weapons.

The goal of the AMSTE program is to develop and demonstrate a new capability to target moving surface threats from long range and to rapidly engage them with precision, standoff weapons. AMSTE offers a robust all-weather approach that permits high-quality tracking of individual target vehicles from nomination though engagement. And it supports the use of low-cost, GPS-guided, precision weapons to minimize collateral damage by adding the ability to provide aim-point updates to a weapon in flight.

There are a number of critical challenges that AMSTE will need to address to be successful, such as tracking accuracy, weapons delivery, combat ID confidence maintenance, and affordability.

Tracking accuracy is addressed through the use of tactical networks to share data from multiple GMTI sensors, each viewing a moving target with its own distinctive geometry and then fused into a single tracking solution. This fusion takes place within advanced tracking algorithms, which maintain multiple models of target behavior to provide robust track against maneuvering targets.

Precision weapons delivery in AMSTE is supported by providing a weapon in flight with continuous moving target position updates from the GMTI tracker solution. The updates can be sent to the weapon in real time over a weapon data link, making the weapon just another node within the targeting network.

A critical piece of the AMSTE concept is the ability to preserve the Combat ID of a particular target under track from initial target nomination through weapon endgame. This requirement for track maintenance has led to work on feature-aided tracking, which utilizes measured target signature features as "fingerprints" to enhance track association performance.

Finally, to achieve the desired affordability, AMSTE will need to make maximum use of existing capabilities to focus on modification, integration, and application of existing and emerging sensor, weapon, and network subcomponents to achieve new system-of-systems capabilities.

In the past year the AMSTE program completed its first series of flight tests designed to demonstrate a number of components of the AMSTE endgame—two or more GMTI sensors performing high-update, rate measurements of a nominated target, algorithms to gridlock and georeference the incoming data, a precision fire control tracker to fuse the sensor reports into a target track, and a mechanism to update a weapon in flight with tracker-derived coordinates to close with a maneuvering target.

Last August the AMSTE team for the first time demonstrated the ability to establish track against a maneuvering target using GMTI data from U-2 and Global Hawk sensors. The data was passed to a modified Maverick missile, which successfully engaged the target. In late August, we conducted tests using GMTI data from Joint STARS and a surrogate for a Joint Strike Fighter, fusing the data in an onboard tracker and using the fused track to pass aim-point corrections to a JDAM-like gravity weapon in the air. The tests demonstrated that an AMSTE system-of-systems concept was viable and that the AMSTE objective of achieving a sub-10m total weapon delivery error was achievable.

We are currently in the middle of our 2002 flight test activities. These tests are focused on using signature-aided tracking techniques to maintain continuous track on targets of interest for extended durations even when the target engages in complex maneuvers, starts and stops, intermixes with civilian traffic, or is temporarily obscured by terrain or foliage. This summer we will also be working with a wider variety of inventory weapon systems, including the JDAM and JSOW weapons.

Let's switch focus to the AT-CUBED effort. The AT-CUBED program is developing and demonstrating network-centric targeting technologies required for lethal Suppression of Enemy Air Defenses (SEAD). The specific focus is on mobile SAMs that employ shoot-and-scoot tactics.

The AT-CUBED approach is to network digital radar warning receivers so that platforms of opportunity can share information about pop-up targets. The platforms compose an ad hoc baseline network to provide very rapid target geolocation with sufficient precision to employ generic shoot-to-coordinate weapons. This capability will allow us to counter the common tactics of emitter shutdown and rapid relocation.

An example AT-CUBED networked targeting process would proceed as follows:

- First, any AT-CUBED collector (a fighter, UAV, or other platform) will detect and classify a target emitter.

- This AT-CUBED collector will broadcast a request for emitter collection to other AT-CUBED collectors. These requests include information about the target type and RF parameters of interest.

- Any responding AT-CUBED collectors in the area will automatically tune, collect, and relay appropriate measured parameters and own position and velocity to the requestor.

- The multi-ship data reports are collected and processed to generate a precision estimate of the threat emitter position, which can be used to target a precision-guided munition against the threat.

A wide array of targeting processes and algorithms are being explored in the AT-CUBED program all focused on resolving the daunting technical issues associated with this lethal SEAD concept.

There are a number of technical challenges that will be addressed by AT-CUBED. AT-CUBED must function opportunistically in emitter side lobes at very significant ranges. Accordingly, highly sensitive receivers with high-dynamic range will be required. These receivers will "hear" many emitters in the theater of operation and must have the capability on their own or through the network to establish common pulse trains very rapidly with sparse or low signal-to-noise data. Very precise time and frequency measurements must be made to support ambiguity resolution and the required geolocation precision. Further, precise navigation will be required to register all of the participants in seven-dimensional space—position, velocity, and time.

All of this must occur in an environment that includes multi-path effects and must work against threat systems that are highly agile. Techniques that leverage the multi-ship nature of AT-CUBED are being developed to ensure robustness in the most stressing environments against the most stressing threats.

The AT-CUBED program is now entering its initial flight test period. The program has developed an airborne data collection and demonstration system that will be flying for the first time in the next few weeks. The system will be capable of demonstrating the AT-CUBED performance goals in the air in real time. It will be highly instrumented and will collect data to explore a very wide range of multi-ship, tactical, targeting approaches.

The system consists of three T-39 jet aircraft equipped with AT-CUBED capable receivers, commercial-off-the-shelf GPS/IMUs, Link-16 data links, and real time processors and software. The aircraft will be operated in a variety of test configurations against realistic emitters on the Western Test Range to assess and demonstrate AT-CUBED performance.

In some cases networked targeting performance is limited by the capacity, latency, and rigidity of existing tactical networks such as Link-16. For instance, some promising cross-platform coherent approaches for targeting emitters can take 10s of seconds to reach a solution simply due to the data transfer limitations. To fully exploit the promise of networked targeting, advances in tactical networks are required. The network must be thought of as an integral part of the targeting systems and, therefore, as an integral part of the overall weapon system. Peter Highnam will follow me with a discussion of IXO work in the area of advanced data link development for network centric engagement.

In summary, the DARPA information exploitation office is pursuing networked targeting through application programs such as AMSTE and AT-CUBED. Both programs share the concept of dynamically coupling multiple sensors to permit precision targeting although each addresses a different application domain with different challenges and technology requirements.

Where do we go from here? We are looking for new ways to apply network-centric engagement in increasingly complex domains. For example, one domain will be urban environments where the three-dimensional nature of the terrain and the close proximity of non-combatants present significant challenges to precision strike operations.

We are interested in highly integrated, network-centric surface combat, using tools and systems organic to a light mobile force.

We are very interested in exploring network-centric engagement of increasing lethal but highly variable irregular combatants, including the engagement of dismounted forces with light but highly lethal arms.

We are interested in exploring network-centric approaches to target engagement in dense foliage, fusing remote and close-in sensor data to permit accurate and effective response to targets under canopy.

Each of these applications offers new challenges not only with respect to the sensor, weapon, and C2 technologies being brought to bear, but also in the system design, interaction, automation, and integration required to close the targeting loop quickly in a highly dynamic environment.

Networked targeting represents a fundamentally different way of performing strike operations, and might require a different approach to technology development—one that focuses on integrating system-of-systems and examining cost/benefit tradeoffs across the kill-chain. Such an approach offers an excellent opportunity for early experimentation with operational users to co-develop concepts of operations and tactics that best utilize the emerging networked targeting capabilities.

Network-centric targeting represents one of the critical pieces of the overall IXO technology portfolio focused on the precision engagement of challenging targets.